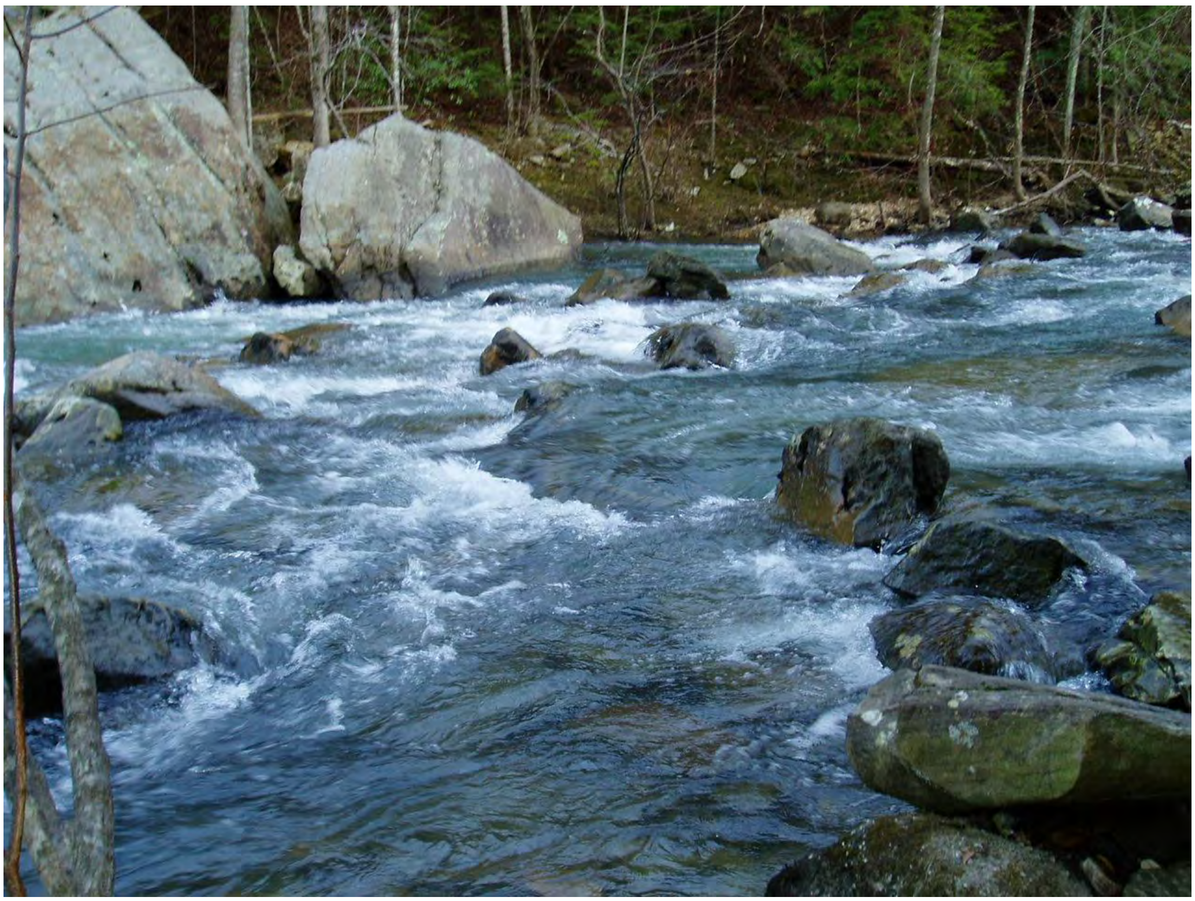
LOWER ROCK CREEK WATERSHED STREAM RESTORATION PROJECT PHASE III
WATERSHED BASED PLAN



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INTRODUCTION

The Lower Rock Creek Watershed lies within the Big South Fork of the Headwaters of the Cumberland River in McCreary County, Kentucky (Fig. 1). Rock Creek originates in Pickett State Park, Tennessee, courses north into Kentucky, and flows 21.9 miles in McCreary County. The Lower Rock Creek Watershed is predominately forestland managed by the U.S. Department of Agriculture Forest Service (USFS), with pre-law mining. White Oak Creek was placed on the 303(d) list due to habitat alteration due to low pH and metals other than mercury. Acid mine drainage is a low pH, iron and sulfate rich water with high acidity resulting from pyrite exposure during mining. The impacted area of the Rock Creek watershed includes White Oak Creek from Cabin Branch downstream to the confluence with Rock Creek at White Oak Junction, as well as Rock Creek from White Oak Junction to the confluence with the Big South Fork. All tributaries to White Oak Creek and this portion of Rock Creek are included. The proposed Phase III project sites are located within the sub-watersheds of Jones Branch, a tributary on White Oak Creek; and in Roberts Hollow, Paint Cliff, and Poplar Spring Hollow on Rock Creek.

Water quality data was analyzed from 41 portals and seeps in the project area beginning in 1999. Acid and metal loading was calculated for each portal and passive treatment options were explored using the water chemistry analysis for each portal discharge. Acid loading was calculated for each tributary and in the spring of 2000 dosing of selected tributaries with sand-sized limestone particles began. Within two months the flow out of Rock Creek into the Big South Fork of the Cumberland River changed from net acidic to net alkaline. After four months similar results were obtained in White Oak Creek, a major source of AMD to Rock Creek.

In the fall of 2000 construction began on a reclamation project targeting several of the worst AMD sites in the lower Rock Creek watershed. Pyrite-rich refuse was removed from the banks of Rock Creek. Open limestone channels were installed routing AMD through the limestone before discharging into the stream and a modified vertical flow wetland was installed at a site with limited distance between the AMD source and the receiving stream. Dosing with limestone sand continued monthly with permanent dosing stations being established farther upstream in the impacted tributaries. Reclamation continued in the fall of 2002 with the installation of additional open limestone channels routing AMD from mine portals to the receiving streams. Limestone channel lining was placed directly into four severely impacted tributaries of Rock Creek, treating the AMD before it enters Rock Creek. A landslide was stabilized and revegetated and an on-bench acidic pond was eliminated. Dosing of the tributaries with sand-sized limestone particles was reduced as the reclamation in the tributaries was accomplished.

Cooperation between 12 state and federal agencies and conservation organizations has led to major improvements to the water quality in Lower Rock Creek. Funding for reclamation in the watershed was provided by several Task Force partners and included two EPA 319(h) Clean Water Action Plan grants.

Reclamation to date has resulted in reductions in sediment load and acid load entering the lower Rock Creek watershed. Acid loading from Rock Creek into the Big South Fork of the Cumberland River has been reduced from 1452 tons annually to near zero after completion of the previous projects. Fish populations are rebounding with increases in numbers, diversity of species, and numbers of intolerant species. At the Paint Cliff section of Rock Creek no fish were found in two out of the three sampling periods prior to the AMD abatement efforts in the lower Rock Creek watershed. In the one sampling period that fish were found prior to construction activities only six species were found. A total of 61 fish representing sixteen different species were found during the last sampling period after completion of the previous AMD abatement projects (Fig. 2). Brown trout, rainbow trout, smallmouth bass, spotted bass, largemouth bass, and rock bass are now routinely found in this once virtually dead section of Rock Creek. (Carew 2007)

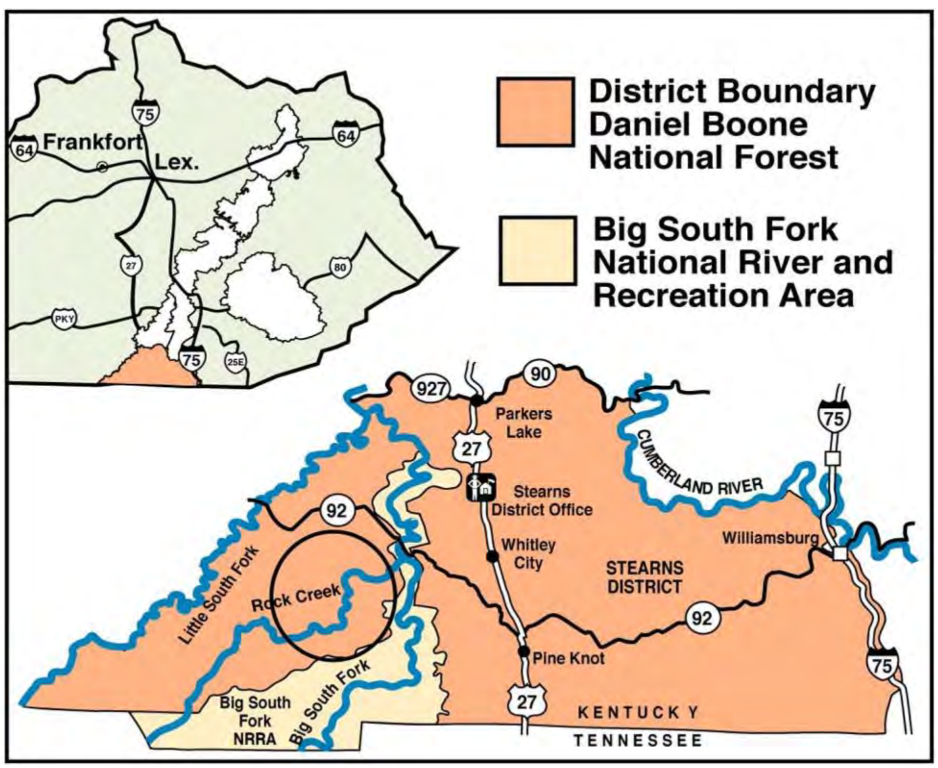

Figure 1. Project area (USFS, 2002).

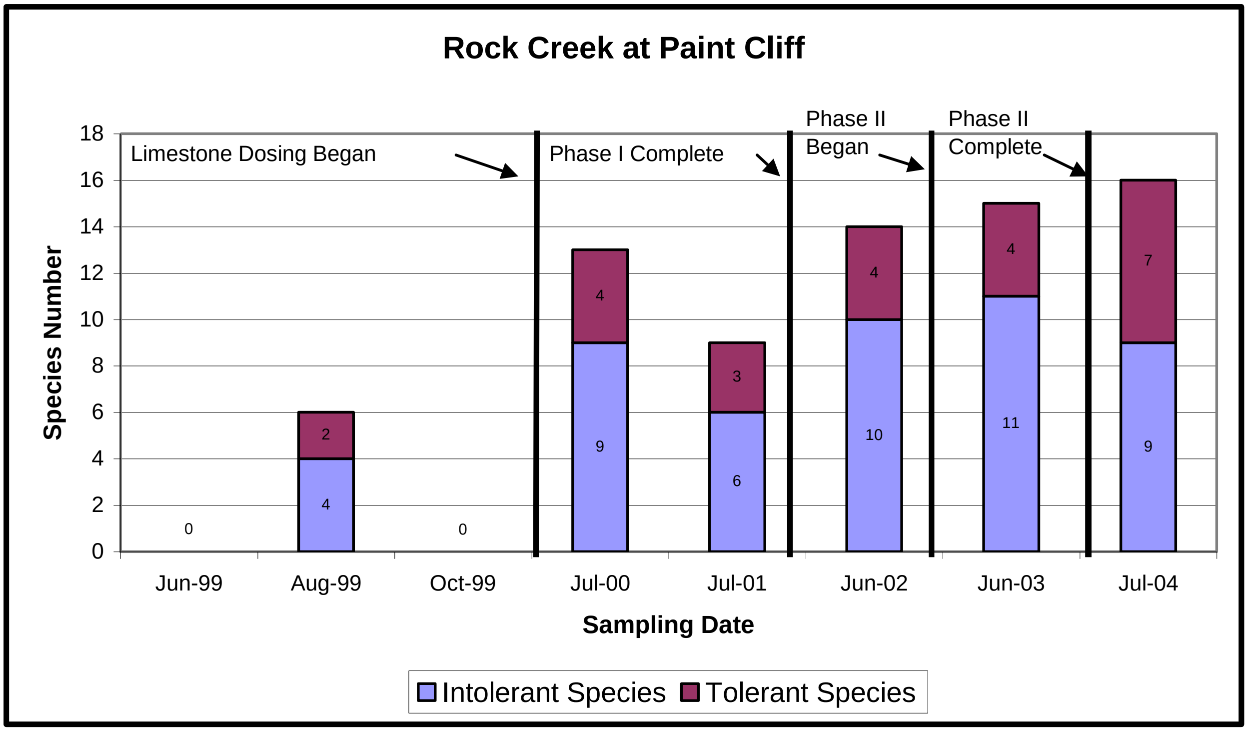

Figure 2. Rock Creek at Paint Cliff fish species.

Geographical Extent

Rock Creek originates in Pickett State Park, Tennessee, courses north into Kentucky, and flows 21.9 miles in McCreary County to its confluence with the Big South Fork of the Cumberland River. The region is used widely for camping, fishing, and hunting. The Lower Rock Creek Watershed (7.3 square miles) is very rural; the small communities of Yamacraw, Fidelity, and Co-Operative organized during coal mining operations no longer exist. Below White Oak Junction acid mine drainage (AMD) from over 40 coal mine portals and eight pyrite-rich refuse dumps decimated aquatic life and rendered the stream virtually lifeless (Fig. 3). The topography is highly dissected with steep stream valleys having elevations ranging from 1400 feet above mean sea level on top of Rattlesnake Ridge to 740 feet above sea level at the mouth of Water Tank Hollow. The steep mountainous terrain limits the types of treatment systems to ones that do not require very much space. Most of the refuse dumps have been stabilized and vegetated to minimize erosion and sedimentation. Drainage from the portals is being treated with passive AMD systems, primarily open limestone channels and limestone sand dosing.

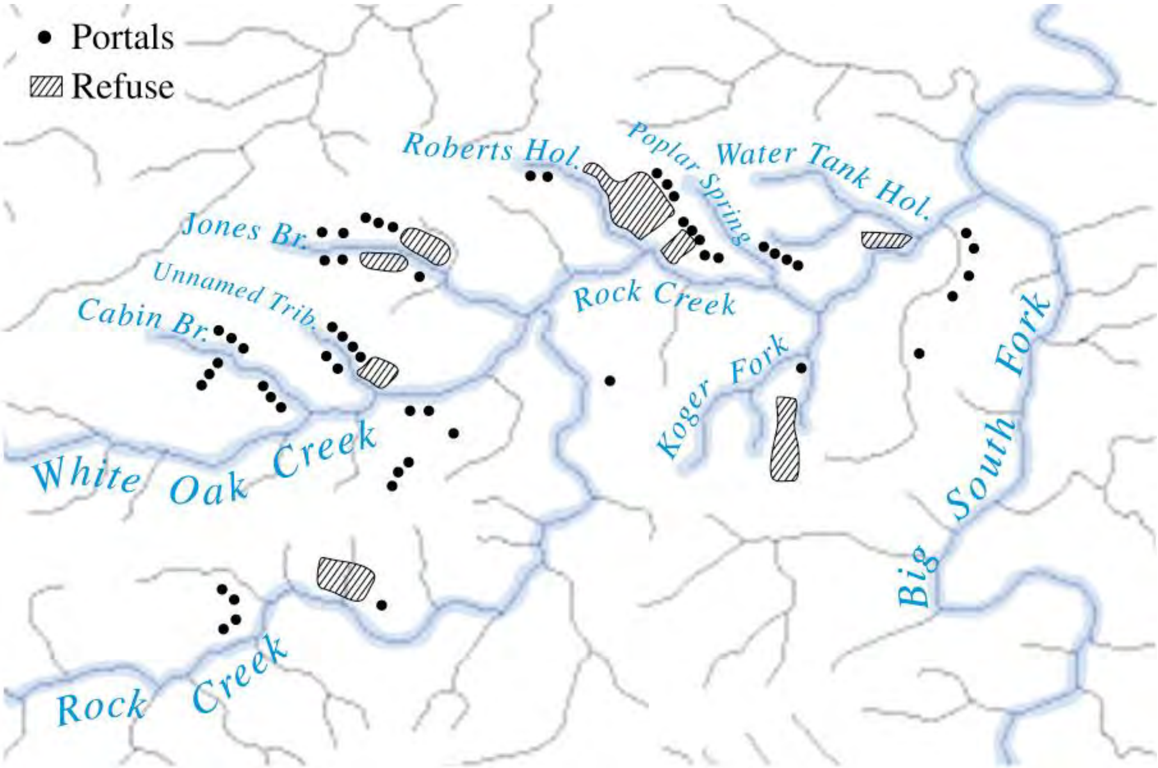

Figure 3. Lower Rock Creek Watershed portals and refuse fill locations.

a. Measurable Water Quality Goals

Total Maximum Daily Load for pH was tentatively approved for Lower Rock Creek and its tributaries in 2004. Increases in the pH and reductions of the acidity have been achieved to meet the watershed's designated uses: the propagation and maintenance of fish and other aquatic life; water contact recreation; and trout water. Due to the improvements previously made Rock Creek was re-listed from non-support to partial support for aquatic life and swimming in the 2004 303(d) List of waters for Kentucky.

Water sampling is being conducted at nine sites. Acidity, pH, and metals content of the drainage are being calculated to determine further reclamation work to be performed. A construction criterion of open limestone channels for treating Acid Mine Drainage assumes that limestone will dissolve at 20% maximum efficiency when armored. Channel lengths will be designed to provide maximum retention and contact time. These treatment devices will provide the alkalinity needed to reduce acidity and raise the stream pH so that limestone sand dosing will no longer be needed.

A series of studies conducted in the early 1970's by Penn State researchers (Pearson and McDonnell, 1974, 1975a, 1975b, 1977, 1978) evaluated the potential of crushed limestone as a passive treatment. The rate of limestone dissolution under AMD loadings was determined and the effect of iron hydroxide armoring was identified. The results based on two years of field observation concluded that fully armored limestone is 1/5 as soluble as unarmored limestone. This factor, combined with the identified dissolution rate in an AMD setting, allows us to estimate the length of a drain and the tons of limestone necessary to treat a specific acid load. This information is summarized in Table 1.

Table 1. The calculations are for a stream cross-section of 3 ft deep by 10 ft wide and an acidity concentration of 1000 mg/1, and assume that limestone will dissolve at 20% maximum efficiency when armored. Under the given conditions, the situation estimates the length of a channel and the tons of limestone which will provide 90% neutralization of the acidity over a 1 hr residence time and 100% neutralization after 3 hrs.

Conditions		1 or 3 hrs Contact Time		1 or 3 hrs Contact Time			
Flow	**Velocity**	**Channel Length (ft)**		**Tons of Limestone**			
				100% Eff		20% Eff	
		1 hr	3 hr	1 hr	3 hr	1 hr	3 hr
gpm	ft/sec	ft		tons			
100	0.02	67	201	169	508	847	2542
200	0.04	134	401	339	1017	1695	5085
300	0.06	201	602	508	1525	2542	7627
400	0.07	267	802	678	2034	3390	10170
500	0.09	334	1003	847	2542	4237	12712

*From Pearson and McDonnell, 1974.

Using this table to determine contact time AMD drainage and limestone we expect to reduce acid loading from Jones Branch and Roberts Hollow by 50%. Acid loading from Paint Cliff and Poplar Springs AMD drainage will also be reduced by 50% when the mine water is placed in contact with limestone in self-flushing limestone ponds.

a. Causes and Sources of Impairment

Lower Rock Creek and its tributaries were extensively mined underground with Acid Mine Drainage (AMD) from over 40 coal mine portals and eight pyrite-rich refuse dumps left over from underground mining that occurred from the first century of the 1900's through the 1960's. Previous reclamation projects have greatly reduced the impairments to the Lower Rock Creek Watershed. Although Phase I and Phase II of the Lower Rock Creek Watershed Stream Restoration Project were not implemented as watershed based plans the methods used to ascertain sources and eliminate the causes followed watershed based plans. Phase III of the Lower Rock Creek Watershed Restoration Project will concentrate the acid mine drainage abatement efforts in the sub-watersheds of Roberts Hollow, Jones Branch, at Paint Cliff, and in Poplar Spring Hollow to compliment previous work and to insure continued success in these sub-watersheds.

b. Estimate of Load Reduction

Lower Rock Creek watershed Stream Restoration Project Phase III is designed for maintaining the load reductions achieved in previous reclamation projects. Acid loading from Rock Creek into the Big South Fork of the Cumberland River was reduced from 1860 tons (1687 tonnes) annually to near zero. The sub-watersheds of Roberts Hollow and Jones Branch are to be lined with open limestone channels for treating AMD. The sub-watersheds of Paint Cliff and Poplar Springs will be treated with self flushing limestone ponds. These ponds will provide the alkalinity needed to treat the affected water and decrease the dissolved metals and acidity from these sites. We estimate to reduce the acid loading from these four sub-watersheds by 50%.

c. Non-point Source Management Measures

The following Non-point Source Management Measures (BMP's) will be used to reduce acid load, metal load, total dissolved solids, and increase pH. Passive treatment technologies will be used to maintain the load reductions previously achieved and improve the systems previously installed at Paint Cliff and Poplar Springs.

- Soil Amendments – Roberts Hollow refuse area will receive material excavated from Paint Cliff and Poplar Springs sites and agricultural limestone and fertilizer will be added to the soil cover.
- Constructed Wetland – an aerobic polishing wetland will be constructed below the Paint Cliff mine discharge, approximately 6.5 acres is available for construction. A small pond will be constructed to allow metals to settle and then the water will flow through the wetland.

- Open Limestone Channels – introduce alkalinity to acid water in open channels or ditches lined with limestone rock (Ziemkiewicz et al., 1994). Armoring of the limestone with iron hydroxides reduces limestone dissolution, so longer channels and more limestone is required to account for the reduced efficiency. Another problem is that hydroxides tend to settle into and plug the voids in limestone beds forcing water to move around rather than through the limestone. Installing the limestone in steep drains with high flushing rates can minimize plugging.
- Self Flushing Limestone Ponds – directing the Paint Cliff and Poplar Springs discharge points into ponds filled with limestone to introduce alkalinity to acid water. The system will be sized to provide 17 hours of retention time for the first water into the pond before a siphon flushes the pond.

d. Cost Estimate and Source of Funding

The total cost estimate for this watershed based plan is $848,700. Below is the budget for the implementation of the best management practices and descriptions of the planned work for each site.

Roberts Hollow

The Roberts Hollow site has mine portals located above a 40-acre acidic coal refuse fill. Both the mine portals and the refuse are contributing significant acid loading to Rock Creek. Phase III proposes to route the mine drainage and acid seeps through open limestone channels for treatment before discharging into the receiving stream. The main channel of Roberts Hollow will be lined with limestone similar to the technique previously used in Jones Branch and Cabin Branch. A total of 7000 feet of limestone channel for treating AMD will be installed in Roberts Hollow. Agricultural limestone will be applied to the refuse fill and areas with sparse vegetation will be revegetated. Limestone sand dosing will cease in the watershed after completion of Phase III construction. The estimated cost to perform the reclamation at the Roberts Hollow site is $402,300.00.

Jones Branch

The Jones Branch site has several mine portals discharging acid mine drainage into the stream. Upper Jones Branch is lined on both sides with acidic mine refuse. Previous Rock Creek projects installed limestone channels in the drainages above and below the mine discharges. A total of 8000 feet of open limestone channels have been installed in Jones Branch, including 4000 feet in the main channel. The pH in Jones Branch prior to construction ranged from 2.5 to 4.3. After installation of the limestone channels the pH has ranged from 4.0 to 6.3. Phase III proposes to install an additional 2000 feet of limestone in the main channel of Jones Branch. The treatment provided by the additional limestone will result in a further increase in pH and an additional decrease in acidity and dissolved metals entering Rock Creek. The estimated cost to perform the additional reclamation in Jones Branch proposed in Phase III is $167,600.00.

Paint Cliff

The Paint Cliff site has several mine portals and acid producing coal processing refuse contributing to the acid load discharging from the site. This site received extensive reclamation efforts in the initial two Rock Creek projects. A modified vertical flow wetland was installed as well as open limestone channels directing acid water to and from the vertical flow wetland. The treatment limitation for vertical flow wetlands is generally considered to be 300 mg/l $CaCO^3$ equivalent. Acidity values prior to reclamation activities were in the 900 to 1200 mg/l $CaCO^3$ equivalent range. The pH at Paint Cliff ranged from 2.4 to 3.8 prior to reclamation. The pH has ranged from 3.0 to 6.2 after construction. During the sampling period in July 2005 acidity values were1531 mg/l $CaCO^3$ equivalent entering the treatment system and 470 mg/l $CaCO^3$ equivalent at the discharge end of the treatment system. The most economical and least maintenance intensive method for additional treatment at this site is installation of a series of two self-flushing limestone ponds. This relatively new technology is being used on a large scale in Pennsylvania to treat some of the worst AMD sites in that state. The technology has not been tried in Kentucky. It has several advantages over other treatment methods. Because it is self-flushing clogging problems associated with vertical flow wetlands in waters with high aluminum concentrations as found at Paint Cliff are non-existent. Maintenance is far less than an active treatment system like the Aqua-fix treatment method. Limestone is used in the treatment cells instead of hydrated lime or quick lime so pH levels remain below 8.5 eliminating concerns with vandalism or accidental releases of reagents into the environment. Additionally the treatment cells can be sized so that maintenance is infrequent. An aerobic polishing wetland is needed prior to the discharge of the AMD into Rock Creek to settle out the iron and aluminum precipitate. The estimated cost to complete reclamation of the Paint Cliff site is $116,400.00.

Poplar Spring Hollow

The Poplar Spring site has several mine portals discharging acidic water into Poplar Spring Hollow. Previous reclamation efforts in Poplar Spring Hollow have routed the AMD through open limestone channels along the mine bench and down the out slope to the receiving stream. Acidity entering Rock Creek from Poplar Spring Hollow has been reduced but not eliminated and the pH still fluctuates below 4 on occasion. Additional limestone is needed to complete the treatment. The proposal for Phase III includes the installation of a self-flushing limestone pond located on the lower mine bench next to the railroad grade. The AMD will flow from the portals in the existing limestone channel to the self-flushing limestone pond resulting in a net alkaline condition before discharging into the stream. The estimated cost to complete reclamation at the Poplar Spring site is $44,200.00.

The total estimated cost of Phase III of the Lower Rock Creek Watershed Stream Restoration Project is $842,200.00. Funding will come from a 319(h) Environmental Protection Agency grant through the Kentucky Division of Water and Kentucky Division of Abandoned Mine Lands Clean Stream initiative. A detailed cost estimate is attached.

Rock Creek Phase III Stream Restoration Cost Estimate

Roberts Hollow

Class II Open Limestone Channel – 3000 feet x1.5T/ft = 4500T x $18/T	= $81,000.00
Class III Open Limestone Channel (18') – 1000 feet x 4T/ft = 4000T x $18/T	= $72,000.00
Class III Open Limestone Channel (8') – 3000 feet x 3T/ft = 9000T x $18/T	= $162,000.00
Cyclopean Rip-Rap – 50T x $18/T	= $900.00
18 inch HDPE Pipe – 60 feet x $20/ft	= $1,200.00
Roadstone – 400T x $18/T	= $7,200.00
Site Preparation – 6 Acres x $1000/Acre	= $6,000.00
Revegetation – 4 Acres x $2000/Acre	= $8,000.00
Ag. Limestone – 500T x $20/T	= $10,000.00
Limestone Sand – 3000 T x $18/T	= $54,000.00
Total	**= $402,300.00**

Koger Fork

Class II Open Limestone Channel – 1500 feet x1.5T/ft = 2250T x $18/T	= $40,500.00
Class III Open Limestone Channel (8') – 800 feet x 3T/ft = 2400T x $18/T	= $43,200.00
Structure Removal – Bridge – 1 lump sum	= $1,000.00
18 inch HDPE Pipe – 60 feet x $20/ft	= $1,200.00
Roadstone – 100T x $18/T	= $1,800.00
Site Preparation – 2 Acres x $1000/Acre	= $2,000.00
Revegetation – 2 Acres x $2000/Acre	= $4,000.00
Limestone Sand – 1000 T x $18/T	= $18,000.00
Total	**= $111,700.00**

Jones Branch

Class III Open Limestone Channel (18') – 2000 feet x 4T/ft = 8000 T x $18/T	= $144,000.00
Roadstone – 200T x $18/T	= $3,600.00
Revegetation – 1 Acres x $2000/Acre	= $2,000.00
Limestone Sand – 1000 T x $18/T	= $18,000.00
Total	**= $167,600.00**

Paint Cliff

Class III Open Limestone Channel (8') – 200 feet x 3T/ft = 600 T x $18/T	= $10,800.00
Self-flushing Limestone Ponds	= $40,000.00
Aerobic Polishing Wetland	= $60,000.00
Revegetation – 1 Acres x $2000/Acre	= $2,000.00
Limestone Sand – 200 T x $18/T	= $3,600.00
Total	**= $116,400.00**

Poplar Spring

Self-flushing Limestone Ponds	= $36,000.00
18 inch HDPE Pipe – 40 feet x $20/ft	= $800.00
Revegetation – 1 Acre x $2000/Acre	= $2,000.00
Roadstone – 300 T x $18/T	= $5,400.00
Total	**= $44,200.00**

Total Phase III Estimate =$842,200.00

e. Education

After completion of the project, and collection and analysis of the post construction monitoring data, AML personnel will present the project results at professional conferences and/or seminars. Kentucky Environmental Education Council (KEEC) will conduct teacher training using Project WET (Water Education for Teachers) materials. Teacher training will include information on acid mine drainage, its effects on aquatic wildlife and will include information on the activities of project and visits to the dosing sites and self-flushing ponds. Instruction will include the chemistry of the water and monitoring data to support improved water quality. A follow up survey of improved knowledge will be conducted by KEEC.

f. Schedule for Implementation

1.	Submit plan to KY DOW and US EPA	February 2008
2.	Pre-Construction Water Monitoring	October 2007- June 2008
3.	Pre-Construction Biological Monitoring	January 2008 - June 2008
4.	Project Design/Survey	Dec. ’07 – February 2008
5.	Project Bid	May/June 2008
6.	Award Bid	July/August 2008
7.	Non Point Source Management Implementation	August 2008 - June 2009
8.	Post Construction Water Monitoring	July 2009 - July 2010
9.	Post Construction Biological Monitoring	July 2009 - July 2010

g. Interim Measurable Milestones

Acid loading decrease of 50% and pH increases of 10 fold (3.5 to 4.5) at Paint Cliff and (5.8 to 6.8) at Poplar Springs discharges before they enter Lower Rock Creek.

h. Criteria to determine loading reductions

The interim targets will be direct measured with water monitoring prior to construction, during construction, and post construction.

i. Monitoring Component

Lower Rock Creek and its tributaries have had extensive water quality monitoring in the past. The water is sampled for pH, acidity, alkalinity, iron, aluminum, manganese, and sulfates. Macroinvertebrate and fish sampling have been done regularly since 2000 to document the recovery of Lower Rock Creek and its tributaries.

- Objectives and Criteria
  1. To collect acid and metal loading data for the Lower Rock Creek tributary of the Big South Fork of the Cumberland River. Lower Rock Creek is being degraded by pyretic coalmine refuse and by seeps discharging acid mine drainage in the Lower Rock Creek Watershed. Monitoring before and after the reclamation will indicate the efficacy of the acid mine drainage abatement techniques used in the reclamation of the site.
  2. To obtain data regarding short term impacts of acid mine drainage mitigation efforts upon the water quality as measured by the aquatic communities of Lower Rock Creek by means of sampling the macroinvertebrate population. Monitoring macroinvertebrates before and after reclamation efforts will indicate the short term effectiveness of this acid mine drainage mitigation project.

- Water Monitoring

Water quality data will be collected from nine sites at the mouths of selected tributaries and in the main stem of Lower Rock Creek. The following parameters will be tested.

Flow (discharge)
pH
Specific conductance
Acidity
Alkalinity
Iron - total and dissolved
Aluminum - total and dissolved
Manganese - total and dissolved
Sulfate
Calcium

Flow - Flow measurements provide information on the proportional effects that pollution sources have on receiving streams. Flow is being measured so loading calculations can be performed on the parameters being analyzed.
pH – The pH of the water is a measurement of the hydrogen-ion activity and gives an indication of the general chemical status to the water, whether the water is acidic or base.
Specific Conductunce – Conductivity is a measure of the water's ability to conduct an electrical current. Conductivity is measured to give an approximation of the amount of solids dissolved in the water. AMD pollution produces elevated conductivity readings since the dissolved metals, sulfate, and hydrogen ions can all conduct a charge.

Alkalininty and Acidity – Acidity is a measure of the amount of base needed to neutralize acid in a solution. Acidity differs from pH in that pH is a measure of the intensity and acidity is a measure of the amount. Water samples can have the same pH but very different acidity values. The acidity concentration affects the type of treatment system that may be designed to neutralize the acid. Alkalinity is a measurement of the capacity of the water to neutralize acid. Below a pH of 4.5 no measureabel alkalinity will be present in the water.
Total dissolve solids – Dissolved solid values are used in evaluating water quality and are useful for comparing waters with one another. The residue left after evaporation can be used as an approximate check on the general accuracy of an analysis when compared with the computed dissolved solids value.
Aluminum, Iron, Manganese – In coal mine drainage, major contributors to acidity are from ferrous and ferric iron, aluminum, and manganese, as well as free hydrogen ions. Aluminum rarely occurs in solution in natural waters in concentrations greater than a few tenths of a milligram per liter. The exceptions are mostly waters of very low pH such as acid mine drainageimpacted waters. Dissolved aluminum in waters having a low pH has a deleterious effect on fish and other forms of aquatic life. Iron concentrations in natural waters are aalso generally small. The chemical behavior of iron and its solubility in water is dependent on the oxidation intensity on the pH of the system in which it occurs. Water in a flowing surface stream that is fully aerated should not contain more tha a few micrograms per liter of dissolved iron at equilibrium in the pH range of about 6.5 to 8.5. Waters that are depleted in oxygen can retain ferrous iron in solution and water with a low pH can retain both ferrous and ferric iron in solution. Manganese is an undesirable impurity in water supplies due to a tendency to deposit black oxide stains. Manganese is often present at concentrations greater than one milligram per liter in acid mine drainage. Manganese usually persists in the water for greater distances downstream fro the pollution source than the iron contained in the acid mine drainage. As the acidity is neutralized, ferric hydroxide precipitates first. Aluminum and iron concentrations in acid mine drainage affects the type of treatment systems that can be used for neutralizing the acidity.
Sulfate – Sulfur that occurs in reduced form in the sulfide minerals is relatively immobile. When sulfide minerals undergo weatherin in contact with aerated water, the sulfur is oxidized to yield sulfate ions that go into solution in the water. Hydrogen ions are produced in considerable quantities in this oxidation process (Hem, 1992).
Calcium – Generally calcium is the predominant cation in river water. The tolerance of many aquatic species to low pH and high dissolved aluminum concentrations is hardness dependent. The higher the calcium concentration the more tolerant some fish are to low pH and high aluminum concentrations.

- Biological Monitoring

Aquatic macroinvertebrates are always in the stream and are continuously exposed to the full range of water quality conditions. Aquatic macroinvertebrates serve as a reflection of stream quality over a period of time. If a pollutant were strong enough it might eliminate many or all of the pollution-sensitive organisms, even though the toxic levels of pollution occurred at irregular intervals. The absence of the sensitive organisms would be a clue that something had upset the stream ecology even though the water might have acceptable chemical quality at the time of sampling.

Biological monitoring stations will be located on the main stem of Rock Creek and in White Oak; the control site will be in Rock Creek upstream of White Oak. Aquatic macroinvertebrates are to be collected in spring and fall by a series of three surber samples per station, along with one triangular kick-net sweep to cover all habitat types in the sample area. All whole samples are to be picked in the field, stored in 70% ethanol, and returned to the DAML Frankfort office for sorting and identification to the lowest possible taxon. After sorting and identification, the data will be evaluated using the modified Hilsenhoff Biotic Index (HBI) (Lenat, 1993) to determine the overall pollution tolerance of the macroinvertebrate community and the degree to which the habitat is impaired. Other metrics to be used include the Total Number of Individuals, Ephemeroptera/Plecoptera/Trichoptera Richness (EPT), and Percent Dominant Taxon. Also, comparison with background data collected since 1999 may be used to estimate impacts to the aquatic habitat.

Fishes are to be collected in early summer by the use of a Smith-Root model 12A battery powered backpack electrofishing device. Fish collected are to be identified in the field when possible, with voucher specimens being returned to the lab for positive identification. Identification will be to the lowest possible taxon. Type specimens are to be preserved in 10% buffered formalin for 1-2 weeks, then rinsed and transferred to 70% ethanol for long-term preservation and storage. After final identification has been completed, the data will be evaluated using the Index of Biotic Integrity (IBI) to determine the overall structure and health of the piscid community as an indicator of aquatic habitat health. Also, Catch Per Unit of Effort (CPUE) of shocking time will be considered as a measure of relative abundance.

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Site - Paint Cliff Mine Portal Drainage

Station number: Lat: Long: Drainage area: Unknown

Laboratory results

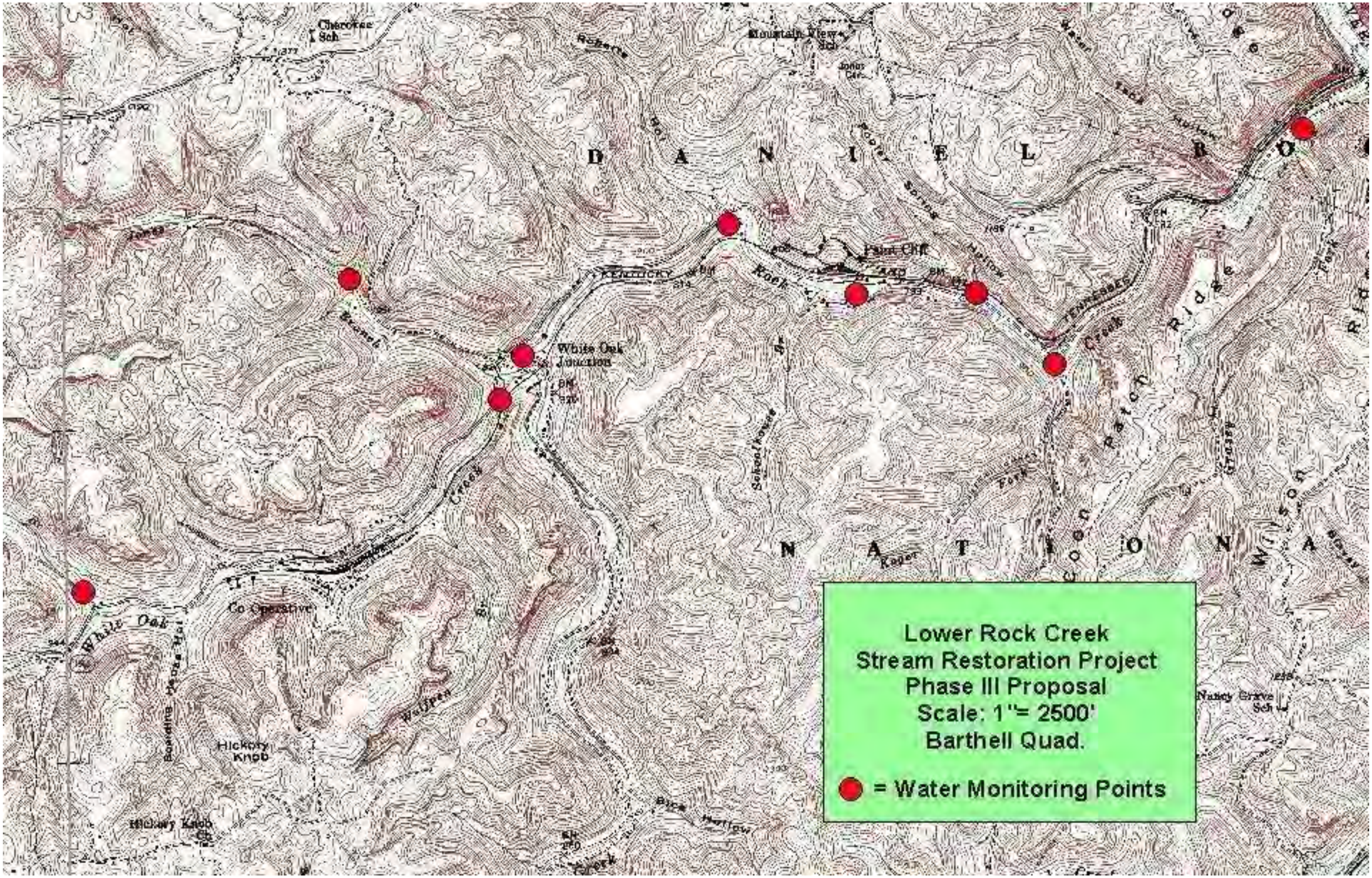
Sampling date	Discharge cfs	pH Lab	pH Field	Cond. Lab	Cond. Field	Alkalinity mg/l CaCO3	Acidity mg/l CaCO3	TDS mg/l	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Su c r
November 29, 2007		3.63	3.9	2970	3430	0.0	1372.0	1680	182.00	54.90	4.96	47.10	45.00	11.70	10.90	

Site 14 - Rock Creek below Grassy Fork at Yamacraw

Station number: 3410597 Lat: 36.71508 Long: -84.54687 Drainage area: 62.64 sq. mi.

Laboratory results

Sampling date	Discharge cfs	pH Lab	pH Field	Cond. Lab	Cond. Field	Alkalinity mg/l CaCO3	Acidity mg/l CaCO3	TDS mg/l	Calcium, total, mg/l	Aluminum, total, mg/l	Aluminum, dis., mg/l	Iron, total mg/l	Iron, dis. mg/l	Manganese total, mg/l	Manganese, dis., mg/l	Sulfate, dis. mg/l
Jan. 25, 2005	40.000	6.46	7.4	99	104	19.0	0.0	66	5.28	0.00	0.00	0.91	0.43	0.11	0.10	35.00
Feb. 25, 2005	160.000	6.05	7.0	68	79	13.0	0.2	49	5.38	0.00	0.00	0.64	0.15	0.10	0.07	21.00
Mar. 30, 2005	201.570	6.75	7.1	66	69	20.0	0.0	39	2.32	0.42	0.23	0.99	0.44	0.13	0.12	17.00
April 25, 2005	46.290	6.80	7.2	103	115	20.0	0.0	59	8.20	0.35	0.23	1.83	0.38	0.13	0.13	36.00
May 27, 2005	51.050	7.03	7.2	97	105	22.0	0.0	52	9.96	0.16	0.00	0.97	0.17	0.10	0.09	25.00
June 24, 2005	10.870	7.57	7.5	165	188	41.0	0.0	89	18.70	0.24	0.05	0.85	0.05	0.08	0.05	45.00
Apr 23, 2007	70.000	7.12	7.1	98	80	25.0	0.0	44	6.00	0.00	0.00	0.60	0.20	0.10	0.07	23.00
Jul 30, 2007	16.600	7.02	7.3	156	160	45.0	0.0	70	18.30	0.50	0.30	0.10	0.10	0.06	0.06	25.00
Oct 22, 2007	3.500	6.60	7.0	271	250	68.0	0.0	128	22.40	0.00	0.00	1.70	0.40	0.03	0.03	65.00


Lower Rock Creek
Stream Restoration Project
Phase III Proposal
Scale: 1"= 2500'
Barthell Quad.
= Water Monitoring Points
D A N I E L B O
N A T I O N A
White Oak
Junction
Paint Cliff
Co Operative
Hickory
Knob
Hickory Knob
Cherokee
Sch
Nancy Grave
Sch
White Oak
Creek
Tennessee
Rock
Patch Ridge
Wilson